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Classification of Raw Silk

By

Mechanical Tests

WARREN P. SEEM



Classification of Raw Silk

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Giving Rules Governing the Operation
of the Gauge Reel and Cohesion Machine
as Developed by Warren P. Seem

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Preface

THE purpose of this pamphlet is to place at the disposal of those adopting the Gauge Reel and Cohesion Machine for the measurement of Evenness, Cleanness and Cohesion, a set of rules and tables with which to determine the relative value of each quality, reduce same to a common value and show its application in the classification of raw silk. I desire to acknowledge the courtesy of the Klots Throwing Co., in the development of the Gauges and the Schwarzenbach Huber Co., in the development of the Cohesion Machine, at whose expense and direction these tests were brought to the present stage of perfection in the interest of and for the benefit of the silk trade of the United States.

The author has been duly authorized to perfect the machines and place them on the market at his own expense. This pamphlet is furnished free to those purchasing a Cohesion Machine or a set of Gauges. As numerous calls have been received for these tables and rules, the author is obliged to ask a remittance of \$1.00 per copy from those not ordering machines so as to cover this initial expense and provide funds for the standardization of tests.

Altoona, Penna., May, 1919.

WARREN P. SEEM.

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Classification of Raw Silk

Evenness

Evenness of the cloth is in a direct relation to the number of fine and coarse threads found in a fixed yardage as I propose to show by the graphic description following:

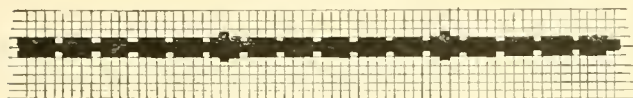


FIG. 1.

The sketch shows the fine and coarse threads woven as the filling, single, in the proportion of 5 fine to 1 coarse, with 3 regular size threads between, to present a good illustration. As the purpose of the sketch is to show the relation of fine and coarse threads to the evenness of the cloth, the frequency in which the regular threads occur is immaterial and is therefore not given in the same proportion as they appear in the test as that would make the sketch too large. Each square represents the cross section of a thread, the fine thread to represent 10 deniers, the coarse 20 deniers, the regular size 15 deniers.

It will be observed that where the coarse sizes appear the unevenness is worse but we cannot view the increase in the thickness of the cloth from the thin part made by the fine thread but must view it from its average thickness made by the regular size thread; a fine thread makes the cloth thin and weak, whilst a coarse thread makes the cloth thick, and when twisted is dull in shade, or causes streakedness. A cloth to be even must lack both the extreme fine and coarse threads; viewing them both from the average thickness of the cloth, the one is as serious as the other, therefore it will be observed that the less fine and coarse threads there are the evenner the cloth and the more fine and coarse appear the more uneven the cloth.

In throwing Organzine when two threads are doubled together of the proportion 1 to $2\frac{1}{2}$, even with the most even doubling, the coarse size will wind around the fine and give the thread a corkscrewed appearance; the greater the difference the more marked will be the corkscrew. The very fine threads, however, present another condition and that is they overstretch and do not contract the same as the regular size and make a bad corkscrew, therefore again we have the same relative condition and the evenness of the Organzine is in proportion to the number of fine threads found in the raw thread. The fine, in addition to making the threads thinner and corkscrewed, also makes the thread 33 per cent. weaker, that is the fine thread generally breaks 33 per cent. lower than the combined strength of both threads of average size. The coarse thread twists up a duller shade, causes streakedness and gets stuck and breaks in the reed when using a fine reed.

Can the evenness be determined by the ecart or spring of sizing skeins? No, as the short fine and coarse even up. Can the relative evenness be determined by the weight total of the sizing skeins above and below the average and their aggregate weight be compared with that of the same number of skeins of average weight or any other mathematical computation from the sizing? No, as the more short uneven lengths there are the more they even up as the following illustration shows.

A lot of Shinshiu No. 1 showed on sixty sizings, skeins of 225 metres a range of from ten to sixteen deniers or a spring of six deniers. A Gauge test showed on 300,000 yards:

135 Very Fine threads under 6 deniers
315 Fine threads under 10 deniers
210 Coarse threads over 20 deniers

One of the most uneven silks ever tested.

Here is the situation: when the fine and coarse threads are very few, say twenty to every 300,000 yards, then they come only once on the average in every 15,000 yards and generally get into one sizing and give a false relative value and when they are many they get so close together that they average up with the coarse and again give a false relative value.

In valuing evenness we must remember first that it is only the extremes that count in working results and the quality of cloth. A very fine thread which always breaks

either in throwing or weaving is just as serious from a working point of view if only one or two inches long as when 100 inches long. 100 very fine are 100 times worse than one very fine. Take the fine ranging from six to ten deniers on a 13/15 denier thread and the coarse over twenty deniers are the ones that pass through and get into the cloth and cause the unevenness that becomes noticeable and lowers the quality of the fabric.

In valuing evenness we need consider only the threads one-third under and over the average size and our test for evenness must be one that will show this truly in the easiest, simplest and quickest way. The fine and coarse threads average between five inches and twenty-five yards. One fine or coarse streak five inches long would not be as bad as if it was twenty-five yards long, but 180 fine streaks five inches long or the equivalent of the twenty-five yards length would be decidedly worse than the one spot twenty-five yards long, so also would 600 streaks in fifteen yards of cloth be much worse than thirty streaks of the same average length.

The point I desire to make is that unevenness is in proportion to the number of very fine, fine and coarse threads regardless of their length and that a test for evenness must show these three conditions regardless of their length, which cannot be done with sizing skeins no matter what length they are reeled. A number of Japanese Inspectors were approached on the uniformity idea shortly after the several articles were published and they said that they could meet the uniformity idea with No. 1 stock and according to the results we have had recently they appeared to have accomplished it very well, indeed, much to our regret.

Is then the practice of judging the evenness by the spring faulty and this custom that has been in vogue for years without any merit? No, when the fine and coarse threads are few they come so far apart that rarely more than one fine or coarse gets into one sizing skein, and they either increase or decrease the weight of same as the case may be; then the spring is a true indicator of evenness. Experienced inspectors never used it as a definite method of judging evenness, only as a sign or an assistance to the inspection. I have found it holds true only in inspecting XX and XXX silk and when the stock is under these two grades then the fine and coarse threads come frequently enough to even up, even on 225 meter sizings, and no dependence can be placed on same.

Should the same tables for evenness be used on coarse sizes as on fine? No, as it is easier to reel a coarse size evenner than a fine size as the following example shows: We will assume that a cocoon fibre average $2\frac{1}{2}$ deniers; a 11/13 denier would then be the product of 5 cocoons and the running out of one fibre would affect the size $2.5 \div 12.5$ or 20 per cent. On a 25 denier it would affect the size $2.5 \div 25$ or but 10 per cent.; a 7 denier $2.5 \div 7$ or 36 per cent. A tabulation of the following tests shows that as the sizes get coarser the evenness becomes better.

8 Lots 16/18	Very fine	0	Fine	63	Coarse	11
23 Lots 18/20	Very fine	0	Fine	64	Coarse	18
14 Lots 24/26	Very fine	0	Fine	30	Coarse	4
5 Lots 28/30	Very fine	0	Fine	12	Coarse	1

Upon the basis of this information and a summary of a great number of lots on the various sizes I have divided the evenness tables into 3 divisions, thus:

11 to 16 deniers	7 points = 1%
17 to 22 deniers	5 points = 1%
23 to 28 deniers and over	3 points = 1%

Very fine to represent 7 deniers and under on all sizes, but they are to be increased as follows:

11 to 16 deniers	x 4
17 to 22 deniers	x 5
23 deniers and over	x 6

The evenness table to be as follows:

11/16	0 = 100%
	828 = 40%
17/22	0 = 100%
	368 = 40%
23/28	0 = 100%
	276 = 40%

Method of Determining Evenness by Gauge

During the development of the Gauges, before I had the diameter of raw silk as given by Rosenzweig, it became necessary to know at what opening of the Gauges different sizes of silk should be tested; this I determined by taking 10 threads from 10 different bobbins and drawing about 20 yards rapidly through the Gauge by hand and shifting the thread to various openings of it until I obtained a distinct draw on the thread. I then averaged up this result and tested the silk at the average size as determined by method named. During the translation of the French 1904 edition of Serivalor in 1910, I discovered the diameter of raw silk as given by Rosenzweig, and set the Gauges accordingly and was surprised to find that we agreed within one denier.

During these tests I discovered that Cantons gave the same draw as hard natured Japans on a size about 1½ deniers coarser, and that Japan with a strawy hand gave the same draw at from 1 to 2 deniers coarser. The filling required on this nature thread was found to be from 10 to 12 per cent. less, which confirmed the result obtained by the Gauges. I now use on Cantons a 16 Gauge for a 14 silk and strawy Japan a 15 Gauge for a 14 silk. On the Japan the difference in results are so close that there is no need for being over critical on this point, as there is always some doubt as to the average size of the raw tested. As the thread flattens out somewhat in going through the Gauges, extreme accuracy is not required as to the Gauge number.

It can readily be understood how coarse sizes choke up in the Gauges and break down the thread, but as to the fine and very fine, it generally requires a practical demonstration to convince testers that they actually do catch the fine threads. A fine thread is the result of allowing one or more cocoons to run out; then when two or more cocoon fibres are added, by a cast on the running thread, the diameter is increased beyond the average size of the raw which catches and breaks down the thread; as fine threads are due to carelessness of the reeler, that same carelessness also causes many other defects, all of which catch and show up the fine thread. The fine end is not, however, a direct catch of the Gauges, as other defects, but must be looked for on the reel or take-up side of Gauge.

Originally it was planned to get the fine threads by putting an adjustable tension on the paying-off bobbin, regulating it according to the size of the thread, but this was found unnecessary, as the per cent. of fine threads not recorded in a test was made under 1 per cent.; besides as the tester does not tie out all of the fine but just enough to get a thread strong enough to tie up to, there was a question of doubt even to the 1 per cent. error shown. Originally we counted the very fine as 50 per cent. under average size and the fine as 33 per cent. under average size. Skilled silk workers judged this relation of evenness by feel and sight, but in teaching learners a definite method became necessary, which was accomplished by tying a knot on thread thus:



and when the knot passed through at Gauge number at which the silk was tested it was considered a fine; this, however, still left the very fine subject to the judgment of the operator and on coarse sizes different operators showed different results.

Comparisons between working results and the Gauge tests showed that it was necessary to fix a standard size for the very fine and let it represent a size that breaks out in throwing and in weaving in the gum, single, on all sizes of raw and that a positive method of determining the very fine was necessary. This condition was met by calling the very fine 7 deniers and under and determining same by their breaking strength. A silk thread breaking at 4 times its average diameter, expressed in grams, is considered 100 per cent. strong, therefore I set the breaking strength of a very fine at 4 x 7 or 28 grams on all sizes, the maximum breaking point of fine to be 33 per cent. less than the average size tested. As many of the fine threads are only a few inches long it is impossible to use the regular length of 50 centimetres, nor would it be practical as it requires too much time to fasten each thread to the two posts of Serimeter each time a fine thread is found. To save time and adapt ourselves to the length of thread available, a series of breaking tests were conducted by passing the thread over a ¼-inch post of the Serimeter and drawing down on both ends of thread until they broke. This method showed a difference of 13 per

cent. between double the result of a 50 centimetre thread single; the thread was then wrapped once around the post and this result on even silk was exactly double that of the 50 centimetre length single; a test conducted on very uneven silk showed but a variation of 3 per cent.; as the 3 per cent. variation was undoubtedly due to the variation in the silk thread tested, I adopted as the maximum breaking point of very fine threads double, 8 x 7 deniers to 56 grams; the minimum fine as per following table. All very fine threads then are based on a 7 denier double or 7 x 4 x 2 = 56 Grams.

10/12 den. = Avg. 11 — 33% = 7.36 den. x 4 x 2 = 58.88 call 59 Grams.	
11/13 den. = Avg. 12 — 33% = 8 den. x 4 x 2 = 64 call 64 Grams.	
12/14 den. = Avg. 13 — 33% = 8.71 den. x 4 x 2 = 69.68 call 70 Grams.	
13/15 den. = Avg. 14 — 33% = 9.38 den. x 4 x 2 = 75.04 call 75 Grams.	
14/16 den. = Avg. 15 — 33% = 10 den. x 4 x 2 = 80 call 80 Grams.	
15/17 den. = Avg. 16 — 33% = 10.72 den. x 4 x 2 = 85.76 call 86 Grams.	
16/18 den. = Avg. 17 — 33% = 11.39 den. x 4 x 2 = 91.12 call 91 Grams.	
18/20 den. = Avg. 19 — 33% = 12.73 den. x 4 x 2 = 101.84 call 102 Grams.	
20/22 den. = Avg. 21 — 33% = 14 den. x 4 x 2 = 112 call 112 Grams.	
22/24 den. = Avg. 23 — 33% = 15.41 den. x 4 x 2 = 123.28 call 124 Grams.	
24/26 den. = Avg. 25 — 33% = 16.75 den. x 4 x 2 = 134 call 134 Grams.	
26/28 den. = Avg. 27 — 33% = 18 den. x 4 x 2 = 144 call 144 Grams.	
28/30 den. = Avg. 29 — 33% = 19.43 den. x 4 x 2 = 155.44 call 155 Grams.	

A scale was then rigged up as per following sketch, which also shows method of using same:

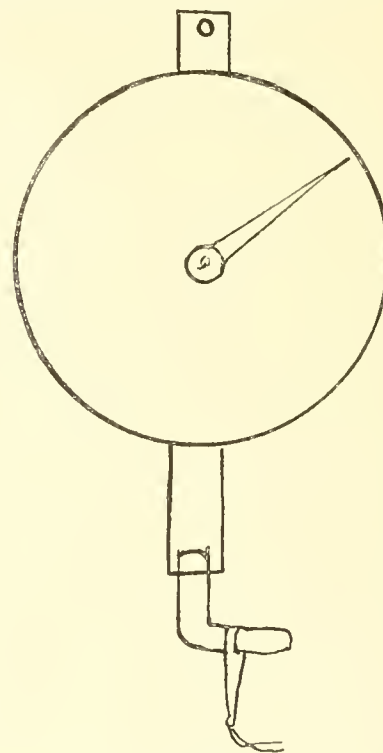


FIG. 2.

The uncleanness of a silk thread is represented by the following defects:

Slugs	
Nibs	
Bad Knots	Cocoon defects
Waste	
Split Threads	
Bad Throws	Reeling defects
Corkscrews	
Hairiness	

Slugs and nibs are made by the worm and we call them cocoon defects. A nib is a small slug; when they are about the size of two raw knots, or are oblong, then call them slugs; if very large call them large slugs. The purpose is to distinguish between the large and small defects and reduce their relative value accordingly. The rest are reeling defects and made by the reeling girl. The following prints show the different shapes and sizes of defects named above except corkscrews and hairiness. Corkscrews are so well known that no illustration appears necessary. Rosenzweig calls them "rognose."

Hairiness consists of small loops about 1/64 inch long, and because of their great number look like short hairs standing up on the skeins when looking across the face of same. This hairiness shows in the cloth when the loops appear about 30,000 to 45,000 on 300,000 yards of thread.

They do not catch in the Gauges, if they did it would be very impractical to count them, even when under 30,000 on 300,000 yards of thread. Instead of including them under Cleanness I penalize the quality number 1 per cent. for 40,000 to 60,000 and 5 per cent. when over 200,000 per 300,000 yards. These may be counted on one section of the reel after a layer of silk has been reeled and increased to 300,000 yard basis.

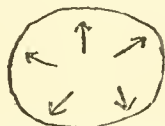
The Gauges have been condemned by critics because they do not catch these minute defects, also because they say that when the thread runs fine then the smaller defects are not removed as thoroughly as when the thread runs coarse and that a perfect instrument to measure Cleanness of the raw silk thread must adjust itself to the variation of the silk thread. Instead of being a fault I find it a distinct advantage. The very worst silk has over a million defects per x yards (300,000). To attempt to count these would be impracticable, besides what benefit would be gained by the knowledge if many thousand of them do not show in the cloth. In counting defects on mirrors no two inspectors would give the same results as the one having the keenest sight would find more defects than the one of duller vision. The thread is run through the Gauges at the average size of the thread tested which, for example, we will take as 14 deniers; let us now suppose that the thread becomes 10 deniers; theoretically it appears that it will not clean the thread as thoroughly as it did when the thread was running through at 14 deniers, but we must not forget that the decrease in diameter is not in proportion to the denier count or as 14:10 but in proportion to the area of a cross section which in turn is in proportion to the square of the diameter.

10 deniers = 0.00183 inches

14 deniers = 0.00217 inches

or as we see a 10 denier is but 15 per cent. less in diameter than a 14 denier silk.

Let us look at it another way: if we cut a thread in two and look at a cross section we see that as it increases in size it spreads out in all directions thus



and when it goes through the Gauges it exposes but two sides to the Gauge and in addition to that is the flattening effect on the thread as it passes through at high speed.

It is quite evident that what we want to know is the relative number of objectionable defects that are on the thread; their size governs this exclusively; therefore, no matter on what size thread they appear the only thing we want to know is, are they large enough to be classed as objectionable. How are we to determine this? By the sense of vision the result varies with the inspectors. A more definite means is therefore necessary, which has been found in the Gauges. These are set to a standard size according to the diameter of raw silk as found by Rosenzweig and given in Serivalor, which are as follows:

Deniers	Microns	Inches	Deniers	Microns	Inches
8	42	0.00165	32	84	0.00328
9	44	0.00174	33	85	0.00333
10	47	0.00183	34	86	0.00338
11	49	0.00192	35	87	0.00343
12	51	0.00201	36	89	0.00350
13	53	0.00209	37	90	0.00355
14	55	0.00217	38	91	0.00359
15	57	0.00225	39	92	0.00362
16	59	0.00232	40	93	0.00366
17	61	0.00239	41	94	0.00370
18	63	0.00246	42	95	0.00374
19	64	0.00253	43	96	0.00378
20	66	0.00259	44	98	0.00386
21	68	0.00267	45	99	0.00390
22	70	0.00272	46	100	0.00394
23	71	0.00278	47	101	0.00401
24	73	0.00284	48	102	0.00402
25	74	0.00290	49	103	0.00405
26	76	0.00296	50	105	0.00414
27	77	0.00301	51	106	0.00418
28	79	0.00307	52	107	0.00422
29	80	0.00312	53	108	0.00425
30	81	0.00317	54	109	0.00429
31	83	0.00323			

One Micron is .001 millimeter or 0.0000394 inches.
One Millimeter equal 0.03937 inches.

The Gauge appears very simple, but here is one condition you must not overlook, and that is that the blades of the cleaner must be $\frac{1}{2}$ inch thick so the long soft slugs do not wriggle through the cleaners; the second difficulty is that as the difference between a 13 denier and 14 denier silk is only .00008 inch, it takes an extremely accurate cleaner and that it is impossible to set it to each size with an ordinary feeler blade and that feeler blades cannot be manufactured so fine. This problem has, however, been solved by the author with the instrument known as the Silk Gauge, which is 2 inches wide, $6\frac{1}{2}$ inches long, and has a range of from 8 to 30 deniers and is ground to an accuracy of one ten-thousandth part of an inch. Experiments show that it is unnecessary with the Gauge to put any tension on the thread, but as all fine threads are accompanied by a defect larger than the average size, they break down and are recorded.

This method is to provide a mechanical inspection test to substitute the inspection of mirrors and overcome the confusion due to difference in vision and judgment of various inspectors in different parts of the world. Nothing is left to the judgment of the operator, it is wholly automatic in its operations.

The Amount of Silk Required to Get Constant Results, Duplicate Tests and Represent the Lot

Twenty skeins selected from different bales of the bale have been found to represent the bale; when less than that is taken the results are reliable if the rest of the bale is like the sample, but to get the average condition and detect variation, 20 skeins are necessary to a bale. Of course you can fool this by putting in a number of bales of very bad silk, but for this the tester must be on guard and when one skein runs very much worse than the others then another set of 20 skeins must be taken from the bales that have been omitted in the first selection. To represent the lot two tests out of five, three out of ten and four out of twenty bales are necessary under present conditions to get the average of a lot. When the run of the bales are known then one test will be sufficient.

The fewer the defects the more silk is required to get constant results as the defects are further apart and consequently a sufficient amount of thread must be used to permit these to average up: the closer the defects the less amount of thread is required. The result of several thousand tests and comparative working results show that when the total number of defects besides raw knots, fine and coarse threads equal 150, then the test can be stopped and the result increased to 300,000 yards by multiplying by the following rule:

20 bobbins 500 yds. ea. total 10,000 yds.x30 =300,000 yds.
20 bobbins 1000 yds. ea. total 20,000 yds.x15 =300,000 yds.
20 bobbins 2000 yds. ea. total 40,000 yds.x $7\frac{1}{2}$ =300,000 yds.
20 bobbins 3000 yds. ea. total 60,000 yds.x 5 =300,000 yds.

Care must be taken that each test represents the 20 skeins. As the Gauge Reel is only equipped with 10 ends change bobbins when test is half finished.

Gauges

The Gauges are made of a high grade tool steel, graduated, tempered, and then ground absolutely true. The fineness of the Gauges is such that the sprains of the metal must be considered and time allowed for this action to subside. (I have had a poor set warp .004 inch out of true during a cold spell where the proper metal was not used.)

The first Gauges were made with blades $\frac{1}{2}$ inch wide, but it was found that there was difficulty in setting them, as they sprung in setting, and when thus set they opened up on the machine. To overcome this they were made with blades $\frac{3}{4}$ inch wide and later 1 inch wide, which solved the trouble.

Method of Setting Gauges

According to Rosenzweig, the diameter of raw silk of 12 deniers is .00201 inch and 27 deniers is .00301 inch; the nearest we can get to .002 inch is 12 deniers and .003 inch is 27 deniers, which are the setting points. It is impossible to measure the diameter of a silk thread with a Micrometer Caliper, as the thread yields or flattens out more or less under the pressure of the Micrometer Caliper. On account of this flattening out and the great variation on silk of the same size, no correction can be determined

upon. The only way we can correctly set the Gauges so that the slot in the Gauges corresponds to the outside diameter of the silk thread is by feel and to make this as near uniform as possible it was found necessary to use weights. It also was found that by using a feeler blade $\frac{1}{2}$ inch wide the same feel could not be had at the lowest point of the Gauge as at the high and also that the measurement was so sensitive that in getting the feel, the Gauges, when made with but $\frac{1}{2}$ inch blades, were opened up. To avoid these errors the feeler blades were then made but $\frac{3}{32}$ inch wide and weighted as follows:

.002	weight 14 grams
.003	weight 17 grams

The ordinary feeler blades bought on the open market are not accurate enough for this work and they must be selected with a Micrometer Caliper measuring by ten-thousandth part of an inch. (No. 75 Micrometer Caliper made by Brown & Sharpe Manufacturing Company is used by the inventor of the Gauges.)

The Gauges are shipped properly set, but if by a mishap they require resetting, tighten up the rear bolt dead tight, then tighten up the front bolt until the .002 feeler blade holds fast at 12 deniers and the .003 feeler blade at 27 deniers. Draw the feeler up and down in slot until it holds its own weight. First clean out the slot very carefully, getting rid of every particle of dust—remember you are working on a very fine measurement. A good grade of tissue paper I find the best for the purpose. Be careful it does not break off and stick fast in the Gauges.

Graduation

The graduations are an arbitrary measurement and based on 15 equal subdivisions between 12 and 27 deniers. The Gauges were made $6\frac{1}{2}$ inches long so as to make the graduations to cover from 8 to 30 deniers.

Operating Gauge Test Speed of Reel

The speed of the takeup of the Reel Fly is to be 250 yards per minute.

Care of Gauges

The Gauges must be kept absolutely clean and free from rust or scum. Oil daily with a good quality of spindle or clock oil, making sure that the oil has run between the two faces of the Gauge blades. Do not permit the Gauges to become choked up with waste, as it is possible to force open the Gauges slightly if waste is wedged in tightly. When the Gauges get choked up with silk thread then use a 1.5 feeler blade to push or pick it out. Put the blade in back of the place you desire to clean out and move it towards the front or open part of Gauge. Do not use a bent feeler blade that scratches the Gauge.

Method of Making Tests

First—Wind from unsoaked silk about 3,500 yards from each of 20 skeins on 20 bobbins, 10 from the under side of skein and 10 from the regular side. Take every other bobbin and threaden up on the Gauge Reel. Shift the Gauges so they all run at the average size of thread. The operator must constantly watch the threads and stop the reel as soon as a break occurs so as to get the yardage uniform. A black mirror should be placed in back of the threads so as to see the threads plainly.

Cohesion

Cohesion is the term applied by Rosenzweig in *Serivalor* to the force that causes the two cocoon filaments to stick together as one compact thread. In physics, cohesion is considered as the mutual attraction of the particles of a solid for one another, and is measured by the amount of force which must be applied in order to overcome it. The term cohesion is generally applied to the mutual attraction of particles of the same substance; adhesion to that of different substances. We thus see then that the term is well applied.

The silken fibre (sericin and fibroin) consists of two filaments (baville, brin) which when issued by the worm through its spinneret are laid side by side and agglutinated together as one cocoon fibre. The force of this agglutination we call Cohesion. The threads that are agglutinated very tightly are dense and firm and resist opening a long time; these we call a very good Cohesion; those that are loosely agglutinated and open very readily we call very poor Cohesion.

The fact that the cocoon fibres consist of two filaments

enables us to measure the Cohesion of the cocoon fibre, but as we use only the reeled thread we are not interested commercially in the Cohesion of the cocoon fibre except as it relates to that of the reeled thread and its relative value in classifying the physical qualities of raw silk.

My experiments on raw silk thread reeled with a long, medium and short croisure or twist indicate that Cohesion is more dependent on the cohesiveness of the sericin than the length of twist in reeling, yet a good twist is essential and must be long enough to knead the thread well together so that it will be well agglutinated and yield a thread with a good Cohesion.

Further observations show first, the importance of having cocoons uniform in quality second, that Lustre is correlated to Cohesion; third, that 90 per cent. of tests show Tenacity and Cohesion practically alike in their relative value.

Investigations are under way to show reasons why 10 per cent. of tests show a variation in the relative value of Cohesion and Tenacity of about 10 per cent.; whether it is due to an error in the method of making the test, relative value of Cohesion and Tenacity tables, or an actual variation in the relative value of these two named qualities.

All reelers agree that to produce a thread with a high Cohesion requires a high grade seed, close attention in sericulture, careful and skilled reeling. It will be observed that since the requirements of a thread with a high Cohesion enhances its value, if in the classification of raw silk we base its physical qualities on Cohesion, then we have a basis that presents a relation true to its real cost to produce and is therefore worthy of your serious consideration.

In weaving single thread in the gum the cocoon fibres constituting the thread must be well agglutinated; if one or more fibres are loosely gummed together then when the threads rub against each other as the shed opens and closes or the harness or reed rubs the thread, then these loosely agglutinated threads open, split off one or more fibres and frequently break.

In skein dye we find that silk with a very poor Cohesion has a tendency to split up in dyeing and cause Lousiness, also that when the sericin is boiled off it produces a skein very wooly or exceedingly loopy in appearance. In spinning Organzine with a thread of low Cohesion sometimes one or more cocoon fibres split off, run a band on bobbin, cause excessive breaks, labor cost and waste.

Measurement of Cohesion

Even though in the loom we find that it is the friction of the harness and reed on the thread and that of the thread upon itself as the shed opens and closes that causes the thread to open and split off, yet extensive experiments show that we cannot measure Cohesion by friction because of the rough character of some silk threads due, I am told, to reeling the thread from cocoons that have been softened in water containing sand and limestone salts. Also there are threads which are so tightly agglutinated that they rub through before opening; still others are so smooth and silky that they resist opening by friction a long time and give very untrue relative results when compared with actual working qualities.

The method of testing resorted to commonly is to separate the fibres of the thread between the thumb and forefinger, noting such results as this crude procedure may make manifest, the personal equation rendering the thumb and forefinger test, at best, no more than a means for arriving at approximate results, which, although better than nothing, are not capable of tabulation and comparison when secured by the efforts of different operators, or even by the efforts of the same operator, working at different times or under different conditions. The sericin or gum or raw silk not only possesses various degrees of adhesiveness, but, also, frequently contains minute particles of foreign matter, such as sand or limestone, which roughens the sericin to such an extent that conclusive results as to cohesion cannot be attained by a mere friction test.

In view of the foregoing, it is the object of this invention to provide a simple but efficient machine whereby cohesion tests on silk thread may be carried out readily, and whereby the results of the tests will be of such a conclusive and uniform nature that they may be compared, thereby producing a standard for cohesion tests.

Experiments covering several years show that Cohesion can be measured by rolling the thread under pressure. I then followed the rule of physicists and measured its relative order, fixed an arbitrary scale of relative values. The number of strokes required to roll open the thread constitutes the unit of Cohesion. The test is made on 200

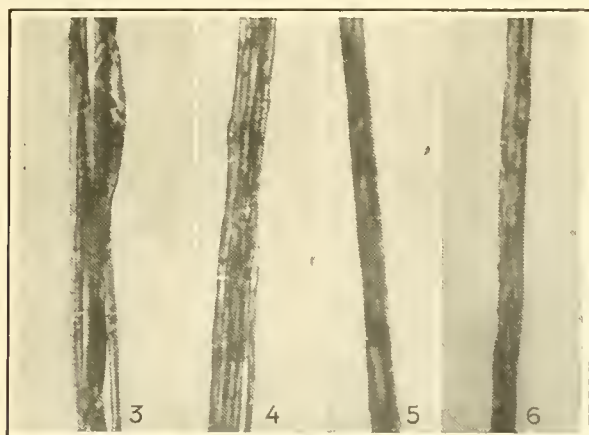
threads, 10 threads from each of 20 skeins. See Fig. 1 for Cohesion machine. Reeled threads requiring but 286 strokes to open showed an open condition of the thread under a magnification of about 150 diameters like Fig. 3.

509 strokes see Fig. 4

827 strokes see Fig. 5

1612 strokes see Fig. 6

It appears that when the threads have a Cohesion over 800 strokes then they are so tightly agglutinated that no voids or openings appear.



FIGS. 3, 4, 5, 6.

Rules for Operating Cohesion Machine

Speed

The speed is to be 108 strokes (full stroke back and forth) per minute. Five strokes more or less will not affect the results.

Oiling

The roller must be kept oiled at its V shaped bearing. Care must be taken not to get oil on roll. It should spin around freely when moved with the finger. In the worm gear casing use a mixture of 50-50 cylinder and machine oil; keep it about $\frac{3}{4}$ full. Oil slide and reciprocating motion about once a week.

Adjusting Roll

The roll must be level and roll evenly on the mirror; care must be taken in adjusting it so as not to bind the roller and retard its movement. This can be tested by moving the roller with the finger and seeing if it spins around freely. The roller must bear uniformly on card the full length of stroke and full width of card. This can be tested by running the machine on a blank card and observing whether the polished place on card, when rolled, is of the same brightness. Use paper liners under card carrier lever.

Care of Roller

It is absolutely necessary that the roller be kept free from dust, scum, rust, oil, perspiration and free moisture. Before using the machine clean off roller with a piece of chalk and wipe off with a dry rag.

Black Cards or Mirrors

Use a good quality of hard black cardboard and avoid using a grade that varies very much in thickness or in its hardness. Soft cardboard retards the opening of threads about 2 to 3 per cent. Use grade like sample shipped with machine.

Preparation of Mirrors

Use an ordinary sizing reel upon which reel, with a spacing of about 60 threads to the inch, 10 threads from each of 5 skeins or a total of 50 threads to a card. Place the mirror under the threads, then paste a gummed label on each end of mirror, gluing down the threads firmly onto the mirror. Make 4 cards for each test or 200 threads all told.

Operation of Cohesion Test

Fasten one mirror firmly on each Cohesion machine, start same and then place threads on roller. If the thread opens up with two or three scratches with the nail of thumb then the card should be examined after the first hundred strokes and every 50 strokes thereafter until all of the threads are opened the full length of the stroke. If it takes 6 to 9 scratches to open the thread, then the machines may be run about 1000 strokes before the cards

need be examined. When the threads once start to open then the card should be examined every 50 strokes.

To examine the threads swing back mirror carrier on rest, remove mirror, bend same so as to slacken the threads, push in a Spatula and bend up against threads and see if all threads are opened the full length of stroke. If not, replace the mirror and continue the test for 50 or more strokes until all the threads are opened the full length of stroke. The number of strokes required to open all the threads fully is the unit of Cohesion for that mirror. The unit of Cohesion for the test is the average of the four cards representing 200 threads.

Note that we use the maximum of each mirror, not the average, but as we use 4 cards the average is obtained as the unit of Cohesion. To take the average of each card requires more time to make a test and a different table must be used. The relative value would not be any different.

Air Conditions

The test should be conducted at a relative humidity of from 65 to 70 per cent. at about 70 to 75 deg. F. No test should be made when humidity is over 75 per cent. or under 50 per cent. The lagging effect of a silk thread is such that if the mirrors are put in a small box with 65 to 75 per cent. humidity for one hour then they may be tested under any reasonable temperature without any appreciable difference.

Starting New Machine

In starting a new machine rub roller with chalk and run it on a mirror without threads about 4 hours so as to remove any grit or corrosion that might have accumulated on roller in transit.

Cohesion Table

Based on the maximum average of 4 cards of 50 threads each on unsoaked silk.

Strokes	Per Cent.	Classification	Application
2200	100		
2100	99	Extra Good Cohesion	Very Good for Weaving in gum single
2050	98		Very Good Organ
2000	97	Extra Good Lustre	
1950	96		
1900	95		
1850	94	Very Good Cohesion	Good for Weaving in gum single
1800	93	Very Good Lustre	Very Good Organ
1750	92		
1700	91		
1650	90	Good Cohesion	Good for Weaving gum single
1600	89		Good Tram
1550	88	Good Lustre	
1500	87		
1450	86		
1400	85	Fair Cohesion	Fair Organ
1350	84		
1300	83	Fair Lustre	Good Tram
1250	82		
1200	81		
1150	80	Fair Cohesion	Fair Organ
1100	79		
1050	78	Fair Lustre	Good Tram
1000	77		
950	76		
900	75	Only Fair Cohesion	Poor Organ
850	74		
800	73	Only Fair Lustre	Fair Tram has a tendency to become woolly
750	72		
700	71		
650	70	Poor Cohesion	Very Poor for Organ
600	69		
550	68	Poor Lustre	Boil off carefully
500	67		
450	66		
400	65	Very Poor Cohesion	Has a tendency to get lousy and woolly
350	64		
300	63		
250	62	Very Poor Lustre	Very Poor Tram.
200	61		
150	60		

NOTE: Cohesion over 2200 strokes usually is very high in lustre and hand.

Winding Test

A true winding test can only be made by counting the breaks on the whole skein from start to finish. As Japan

skeins at 167 thread speed run from four to five hours, it takes too long a time to make a test on the whole skein and a shorter test becomes necessary. After working several methods for a number of years I found that any short method that would be true to the breaks on the whole skein within a maximum variation of fifteen per cent. would be close enough for a winding test. I then made a series of 20 tests on Japan, single and double skeins. Italians, Chinas and Cantons, and from this series found the following method came within the 15 per cent. maximum limit; the series did not vary more than 5 per cent.

Air Condition—Temperature 70 to 75 per cent. at 70 to 75 per cent. Relative Humidity.

First—Select 20 skeins from one bale. We must make our selection from original packages, that is one bale. Whilst most of us buy in five and ten bale lots, the bales are not always alike. A bale, however, generally represents the product of one filature which is not always true of a five or ten bale lot. I have found 20 skeins necessary to represent the average conditions of a bale and give results equal to tests made on 60 skeins. I found 10 skein tests varying too much.

Rub Gums

Gums or reel markings must be rubbed out before winding. On hard gums they can be daubed with a warm emulsion which softens the gums so they can be thoroughly removed.

Skeining or Dandering

Skeins up 10 skeins with under side up, the other 10 regular.

Speed

Rated when test is half completed.

On unsoaked silk with Gums 120 Thread (Yards per minute). On unsoaked silk without Gums and soaked silk 180 Thread (Yards per minute).

Swifts

Twelve stick, Pin Hub unweighted.

Method of Making Test

Make a starting run of fifteen minutes, don't count breaks, then wind 300,000 yards counting breaks.

At 120 thread speed, Run 125 minutes.

At 180 thread speed, Run 84 minutes.

The sum of all the breaks on the 300,000 yards equals winding count.

(For waste and cost tables add eight to count for first end tied up which is the equivalent of the twenty first ends tied up on the 300,000 yards wound.)

The breaks the first half hour are very excessive at times. Break tests made only on the first hour winding sometimes vary as much as 100 per cent. When making a starting

run of but six minutes you still get too many breaks; tests covering many years show that fifteen minutes for a starting run are required to give results representing the actual conditions of bale.

To change the count to breaks per skein on 14/16 denier size divide by six.

QUALITY TEST FORM NO. 3

Tag Sample Date 1/14 Name _____

Gauge Number _____ Quality Gauge 1

No. Ends Tested 10 Speed 167 ft. min.

Test Started 8 Stopped 9.45 Test Time 1.45

Remarks Slugs mostly small

	SUMMARY	
	ACTUAL	300,000 YARDS
Fine <u>11</u>	1	2
Coarse <u>11</u>	2	5
Waste <u>11</u>	6	14
Small Raw Knots <u>11</u>		
<u>11</u>	136	236
Bad Knots <u>11</u>	58	66
Winding Knots		
2-threads		
Nibs		
Slugs <u>11</u>	10	70
Loops	1	2
Split Ends <u>11</u>		
Corkscrew		
Bad Throws		
In Doubt <u>11</u>		7
	255	455

WINDING TEST SHEET FORM NO. 1

Tag Sample Date 1/14 Name _____

Stock & Grade Japan

No. Ends Tested 10 Thread Speed 167

Starting Run Started _____ Stopped 1.15 Time 16 min.

Winding Test Started 1.15 Stopped 2.51 Time 95 min.

Remarks _____

BREAKS: Starting Run. Don't Count These Breaks.	BREAKS: Winding Test. Count These Breaks.	Summary
Fine		
Loose		
Other Defects		
	First End	
	Double Skein	
	Count Total	

Winding Table

Count	No. Swifts Run	Waste 13, 15 Den	Class
		Amer. St-Canton Reel Reels	
18/20	114	0.30%	Very well
21/22	110	0.33	
23/24	105	0.36	
25/26	100	0.39	
27/28	94	0.42	
29/30	90	0.45	
31/32	86	0.48	Very well
33/34	82	0.51	Well
35/36	78	0.54	Well
37/38	75	0.57	Well
39/42	72	0.63	Well
43/46	66	0.69	Well
47/50	62	0.75	Fair
51/54	58	0.81	Fair
55/58	54	0.87	Fair
59/62	52	0.93	Fair
63/66	50	0.99	Only fair
67/70	47	1.05	Only fair
71/74	44	1.11	Only fair
75/78	42	1.17	Poor
79/82	40	1.23	Poor
83/86	39	1.29	Poor
87/90	37	1.35	Poor
91/94	36	1.41	Very poor
95/98	35	1.47	Very poor
99/102	33	1.53	Very poor
103/106	32	1.59	Well for Canton
107/110	31	1.65	Well for Canton
111/114	30	1.68	Well for Canton
115/118	29	1.74	Fair for Canton
119/130	28	1.87	Fair for Canton
131/140	27	1.92	Fair for Canton
141/150	26	2.17	Fair for Canton
151/160	25	2.32	Poor for Canton
161/170	24	2.47	Poor for Canton
171/180	23	2.62	Poor for Canton
181/190	22	2.77	Poor for Canton
191/200	20	2.92	Very poor for Canton
201/210	19	3.07	

Evenness Table

As the relative value of each defect varies, it is necessary to reduce them all to a common value, which is done in the following manner:

Evenness.—Very fine on 11/16 denier multiply by 4
Very fine on 17/22 denier multiply by 5
Very fine on 23/30 denier multiply by 6

Fine.—All sizes multiply by 1.

Coarse.—All sizes multiply by 4.

Average Yokohama Classification

Three per cent. under Best				
Class	11/16 Den.	17/22 Den.	23/28 Den.	%
	0	0	0	100
	9	4	3	99
Very	18	8	6	98
Good	27	12	9	97
	36	16	12	96
	45	20	15	95
	54	24	18	94
	63	28	21	93
Good	72	32	24	92
	81	36	27	91
	90	40	30	90
	99	44	33	89
	108	48	36	88
Fair	117	52	39	87
	126	56	42	86
	135	60	45	85
	144	64	48	84
Only	153	68	51	83
Fair	162	72	54	82
	171	76	57	81
	180	80	60	80
	189	84	63	79
	198	88	66	78
	207	92	69	77
Poor	216	96	72	76
	225	100	75	75
	234	104	78	74
	243	108	81	73
	252	112	84	72
	270	120	90	71
	288	128	96	70
	306	136	102	69
	324	144	108	68
	342	152	114	67
	360	160	120	66
	378	168	126	65
	396	176	132	64
	414	184	138	63
	432	192	144	62
	450	200	150	61
	468	208	156	60
	486	216	162	59
	504	224	168	58
	522	232	174	57
	540	240	180	56
	558	248	186	55
	576	256	192	54
	594	264	198	53
	612	272	204	52
	630	280	210	51
Exceedingly	648	288	216	50
Poor	666	296	222	49
	684	304	228	48
	702	312	234	47
	720	320	240	46
	738	328	246	45
	756	336	252	44
	774	344	258	43
	792	352	264	42
	810	360	270	41
	828	368	276	40

Cleanness Table

Cleanness. These defects are all penalized according to their size and seriousness. All sizes are alike but table of common values different.

Penalties for Cleanness

Waste	x 1
Nibs	x 1/20
Very large slugs	x 1
Slugs	x 1/2
Bad throws	x 1
Very long knots	x 1
Long knots	x 1/2
Loops	x 1/20
Very large loops	x 1/20
Corkscrews	x 1/20

The tables on evenness and cleanness are made up for common values.

Average Yokohama Classification Three Per Cent.

Under Best				
Class	11/16 Den.	17/22 Den.	23/28 Den.	%
	0	0	0	100
	15	11	8	99
Very	30	22	16	98
Good	45	33	24	97
	60	44	32	96
	75	55	40	95
	90	66	48	94
	105	77	56	93
Good	120	88	64	92
	135	99	72	91
	150	110	80	90
	165	121	88	89
	180	132	96	88
Fair	195	143	104	87
	210	154	112	86
	225	165	120	85
	240	176	128	84
	255	187	136	83
Only	270	198	144	82
Fair	285	209	152	81
	300	220	160	80
	315	231	168	79
	330	242	176	78
	345	253	184	77
Poor	360	264	192	76
	375	275	200	75
	390	286	208	74
	405	297	216	73
	420	308	224	72
	442	323	236	71
	464	338	248	70
	486	353	260	69
	508	368	272	68
	530	383	284	67
	552	398	296	66
	574	413	308	65
	596	428	320	64
	618	443	332	63
	640	458	344	62
	662	473	356	61
	684	488	368	60
	706	503	380	59
	728	518	392	58
	750	533	404	57
	772	548	416	56
	794	563	428	55
	816	578	440	54
	838	593	452	53
	860	608	464	52
	882	623	476	51
Exceedingly	904	638	488	50
Poor	926	653	500	49
	948	668	512	48
	970	683	524	47
	992	698	536	46
	1014	713	548	45
	1036	728	560	44
	1058	743	572	43
	1080	758	584	42
	1102	773	596	41
	1124	788	608	40

Tenacity Test

Relative Humidity should be maintained between sixty-five to seventy per cent. at a temperature of seventy to seventy-five degrees F.

Select twenty skeins from different parts of a bale and reel 22½ meters from each of the twenty skeins, making a full length sizing skein of 450 meters. Weight this carefully in deniers and use it as the average size of thread. Cut this skein in two and draw out thirty threads from different parts of the skeins, making the Tenacity Test on a standard Serimetre in the usual manner. To find the relative value, apply strength table or multiply the average size by four and divide this result into the average tenacity, multiplied by 100, shown by test, *c. g.*, Size 14; Tenacity 56; thus:

$$14 \times 4 = \frac{56 \times 100}{56} = 100\%$$

As this test is made for the physical qualities of the thread, not the structural, we must avoid all threads having structural defects in this test.

STRENGTH TENACITY TABLE

Class	%	DENIERS																	
		11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Very Good	106	47	51	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116
	105																		
	104																		
	103																		
	102																		
	101																		
	100	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112
	99																		
	98																		
	97																		
Good	95																		
	93	41	45	49	53	57	61	65	67	71	75	79	82	86	90	94	98	101	105
	92																		
	91																		
	89																		
	87																		
	86	39	42	45	49	53	57	61	63	67	70	74	77	81	84	88	91	94	98
Fair	85																		
	84																		
	83																		
	81																		
Only Fair	80	35	38	41	44	48	52	56	59	62	65	69	72	75	78	82	86	88	91
	78																		
	77																		
	76																		
Poor	74																		
	73	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84
	71																		
	70																		
	69																		
	67																		
	66	29	32	34	37	40	43	46	49	52	55	58	60	63	67	69	71	74	77
Very Poor	65																		
	64																		
	63																		
	61																		
	60	27	30	32	35	37	40	42	45	47	50	53	55	58	60	62	65	67	70

RAW SILK CLASSIFICATION

ALTOONA, PA. Feb. 28th, 1919

LOT NO. Sample

MARK Sample

BALE NO. Sample

STOCK Japan

CHOP Sample

GRADE Ex.Ex.B. SIZE 14.85

APPEARANCE

COLOR		LUSTRE	HAND OR TOUCH	HAIRYNESS PENALTY	SKEIN	GUMS
WHITE IVORY X CREAM	VERY EVEN EVEN FAIRLY EVEN UNEVEN VERY UNEVEN	VERY GOOD GOOD X FAIRLY GOOD FAIR POOR VERY POOR	VERY SILKY SILKY NERVY X FIRM STRAWY SLONGY	VERY BAD 5 per cent. BAD 3 per cent. GOOD 0	ST. AMERICAN IMITATION STRAIGHT CROSSING OTHERS	SOFT HARD NARROW BROAD

MEASURABLE QUALITIES BASED ON 300,000 YDS.

MADE ON 60,000 YDS.

	10M	10M	10M	10M	10M	10M	Total	AVERAGE	EVENNESS	CLEANNESS
WINDING COUNT . 13										
GAUGE TEST										
RAW KNOTS ()	(8)	(9)	(11)	(7)	(5)	(10)	(50)	(250)		
VERY FINE, BKNG. STRAIN UND. 24 GR.									X 1	
FINE, 33% UNDER AVG. SIZE	2	2	4	1		2	11	55	X 4	55
COARSE, 33% OVER " "										
WASTE						1	1	5		X 1 5
VERY LARGE KNOTS	2		1				3	15		X 1 15
LARGE KNOTS										X 1 15
NIBS	7	5	5	3	4	5	29	145		X 1 7
VERY LARGE SLUGS										X 1 15
SLUGS	1	1	1			1	4	20		X 1 10
VERY LARGE LOOPS										X 1 15
LOOPS	14	10	8	12	9	15	68	340		X 1 17
SPLIT ENOS										
BAD THROWS		3	3	2	1	3	12	60		X 1 60
CORK SCREWS	11	24	15	17	13	19	97	485		X 1 24
TOTAL DEFECTS								1125	TOTAL 55	TOTAL 138
TENACITY TEST GRAMS		55							PER CENT. 94	PER CENT 91
COHESION TEST RAW		1775							RELATIVE VALUE 95	per cent.
COHESION TEST SOAKED									RELATIVE VALUE 93	per cent.

QUALITY SCALE

BASED ON

RELATIVE VALUES

%	GRADE	%	GRADE
100		51	
99		50	Best
98	XXX	79	No. 1
97		78	
96		77	
95		76	
94	XX	75	
93		74	No. 1
92		73	
		72	
91		71	
90		70	
89	X	69	1 to 1 1/2
88		68	
87		67	
		66	
86		65	
85	Best No. 1	64	No. 2
84	to	63	
83	Extra	62	
82		61	
		60	

QUALITY SUMMARY RELATIVE VALUES

STRENGTH 95 %

COHESION 93 %

AVERAGE 94 %

EVENNESS 94 %

CLEANNESS 91 %

COMMON VALUE ALL QUALITIES 93 %

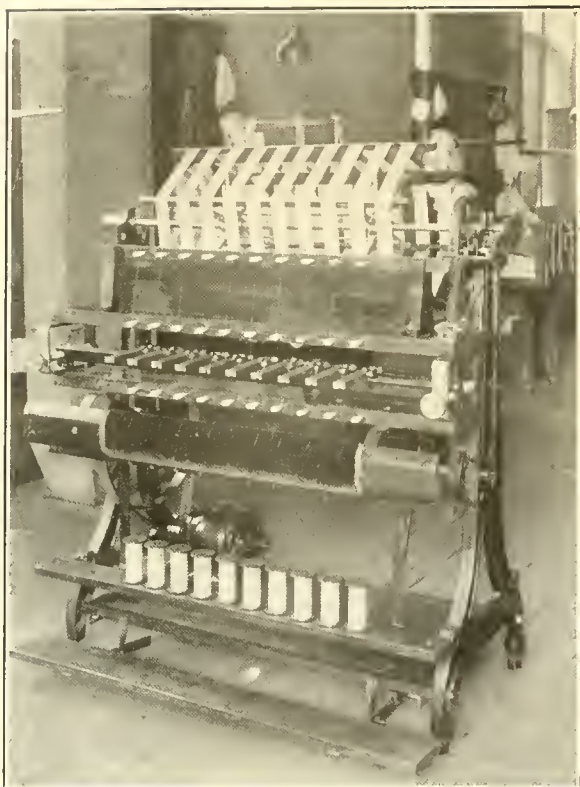
PENALTY -- %

QUALITY No 93 %

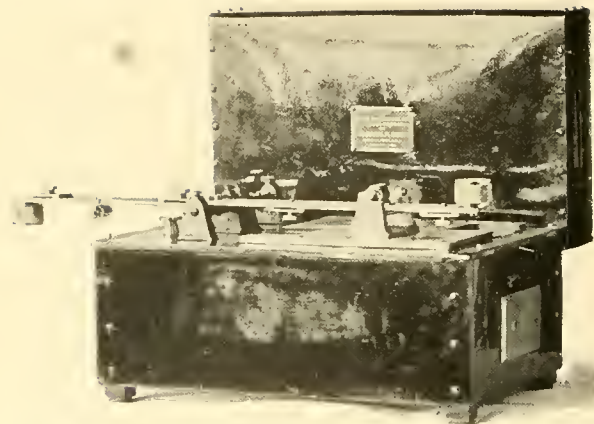
REMARKS:

SIGNATURE A.H.

THROWING DYEING OR WEAVING REPORTS



GAUGE REEL FOR DETERMINING EVENNESS AND
CLEANLINESS OF SILK



COHESION-MACHINE
Patented April 15, 1919



PLATE 3—SMALL RAW KNOTS.



PLATE 4—BAD KNOTS.



PLATE 7—SLUGS.



PLATE 6—NIBS.



PLATE 5—WASTE.

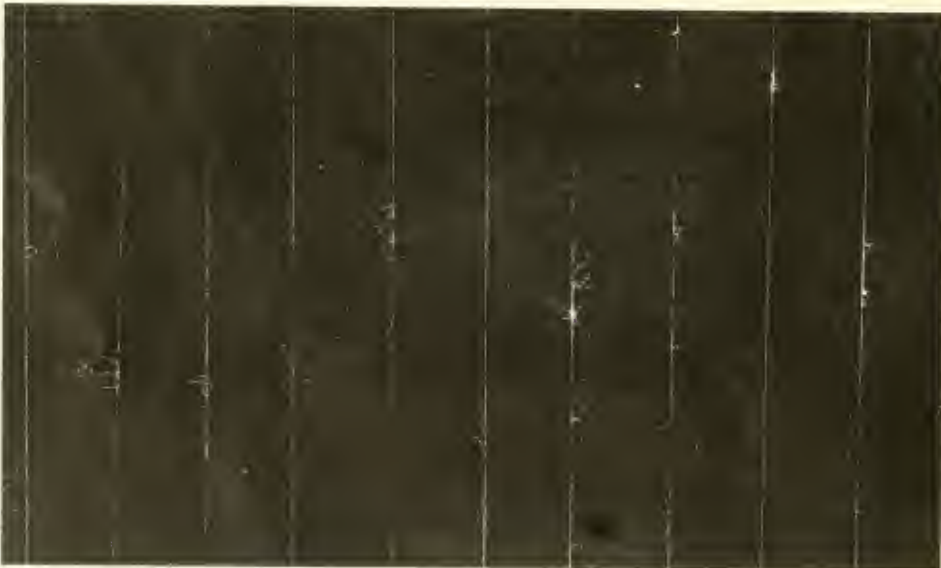


PLATE 8—LOOPS.



PLATE 9—SPLIT ENDS.

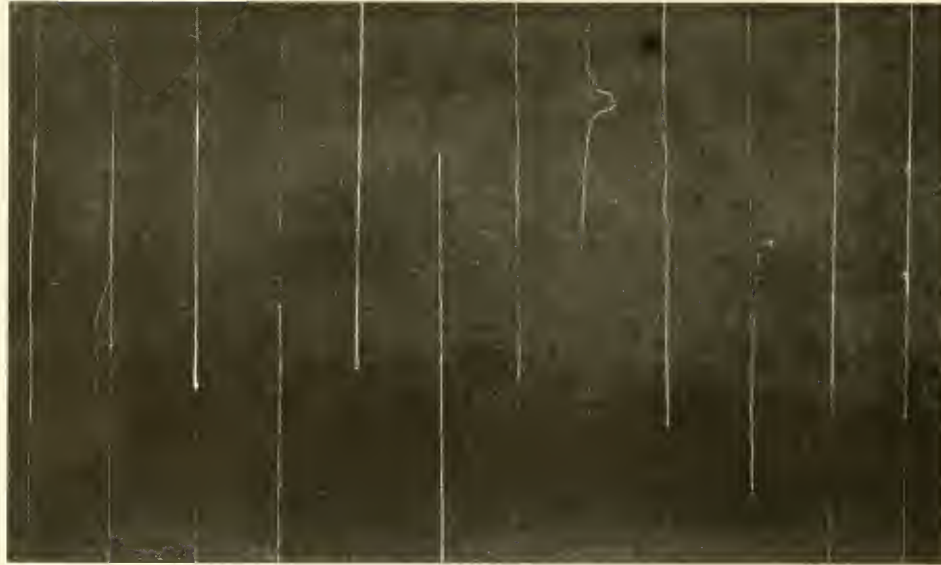


PLATE 10—BAD THROWS, CORKSCREW ENDS.

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